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REVIEW OF THE GILBERT BAY MARINE PROTECTED AREA MONITORING INDICATORS, PROTOCOLS AND STRATEGIES, AND AN ASSESSMENT OF THE GILBERT BAY COD POPULATION

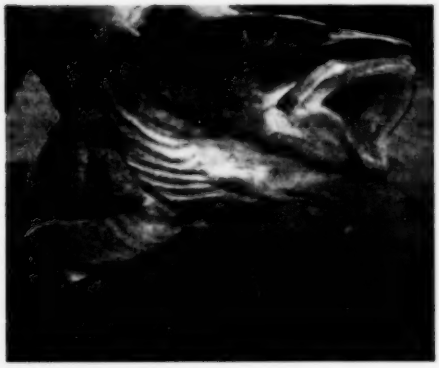

Photo: Corey Morris

Figure 1: Gilbert Bay Marine Protected Area

Context :

In support of the Health of the Oceans Initiative (component 21), Science sector is required to deliver indicators, protocols and strategies for monitoring the individual conservation objectives for established Marine Protected Areas (MPAs).

Monitoring of biological and ecological indicators (and their respective threats) is applicable to: 1) incorporation into broader MPA monitoring "plans" or "programs" (addressed by the DFO Oceans Sector); 2) tracking status, condition and trends to determine if MPAs are effective in achieving their Conservation Objectives; 3) aiding managers in the reveiw of MPA management plans to achieve conservation objectives; and 4) reporting to Parliament and Canadians (ultimately, via the management sector). Therefore, the selection of indicators and protocols for collection and analysis of data must be scientifically defensible.

Although not officially designated as an MPA until 2005, Science in support of the Gilbert Bay initiative has been ongoing since 1998. Therefore, the review of monitoring indicators, protocols and strategies for the Gilbert Bay MPA requires taking into consideration the indicators that have been used to date, advising on their suitability for measuring against the existing conservation objectives for the Gilbert Bay MPA, identifying other potentially important indicators where required, and if appropriate, assessing trends in the available indicator data to assess the status of the Gilbert Bay cod population.

May 2010

Canada

SUMMARY

- The five indicators currently being used to monitor the Gilbert Bay cod population, and their respective sampling and analytical protocols, are appropriate and sufficient to monitor the MPA against its Conservation Objective(s).
- Data from the five indicators currently being used to monitor the Gilbert Bay cod population are sufficient to assess the status of the Gilbert Bay cod population.
- Current indicators used in the assessment of the Gilbert Bay cod population indicate a decline in abundance.
- Current indicators used in the assessment of the demographics of the Gilbert Bay cod population also suggest that the population may decline further due to decline in reproductive potential.
- Given the current status of the Gilbert Bay cod population and the indication of poor recruitment in recent years, the removal of an unknown number of spawners, in the area adjacent to the MPA, by the commercial and recreational fisheries is a concern.
- Further research is required to develop or improve indicators for monitoring natural and anthropogenic pressures on the Gilbert Bay cod population.
- Given recent advances in telemetry and the current telemetric infrastructure in place for monitoring the Gilbert Bay cod population, enhancing the use of telemetry to indicate movements of large cod between the MPA and adjacent areas would prove useful to further understanding sources of mortality of Gilbert Bay cod.
- Reference levels for the Gilbert Bay cod population should be explored to provide a benchmark against which to better determine population status in future assessments.

BACKGROUND

Establishment of the Gilbert Bay MPA

Gilbert Bay is a narrow inlet located on the southeast coast of Labrador approximately 300 km from Happy Valley-Goose Bay. A relatively remote region of the province of Newfoundland and Labrador, the population of the southeast region of Labrador is approximately 3,000. Communities nearest to Gilbert Bay are Port Hope Simpson and William's Harbour.

Local residents were aware of darkly coloured Atlantic cod that overwintered in Gilbert Bay since at least the 1970's (Powell 1987). The scientific study of Atlantic Cod in Gilbert Bay, initially for aquaculture purposes (Wroblewski 1998) dates back to 1996 (Janes et al. 2009). Local residents raised concerns over the sustainability of the local population when the northern cod fishery re-opened in 1998 and fishing efforts in the region targeted Gilbert Bay cod due their

relative abundance compared to that found on traditional fishing grounds (Morris et al. 2002). Subsequently, communities and fish harvesters showed interest in the implementation of conservation measures to protect this unique population, and in 1998, DFO began the first of

several consultations to determine the suitability of Gilbert Bay as a candidate Marine Protected Area under Canada's *Oceans Act*. In October 2000 Gilbert Bay was announced as an official Area of Interest (AOI) by DFO, providing interim protection measures for the site under the *Fisheries Act*.

Gilbert Bay was designated as a Marine Protected Area under the *Oceans Act* on October 11, 2005. In 2007, the Gilbert Bay Marine Protected Area Management Plan – outlining conservation objectives and management actions for the MPA with respect to scientific monitoring, compliance and enforcement, as well as public awareness with the intent to guide and inform management decisions – was released. This Management Plan is scheduled for review and renewal in 2010.

Conservation Objectives for the Gilbert Bay MPA

The MPA regulatory conservation objectives, are part of site specific regulations published in the Canada Gazette. The monitoring program supporting these objectives is aimed at determining the success of the MPA in meeting the conservation objectives.

The primary regulatory based conservation objective for the Gilbert Bay MPA is ***the conservation and protection of the Gilbert Bay cod population and its habitats***.

Gilbert Bay MPA Monitoring

Data on the Gilbert Bay Atlantic cod population has been collected each year since 1998. This cod monitoring program supports the regulatory conservation objectives, through the provision of scientific data and information which can be used to indicate whether the conservation objectives are being met. This review and assessment addresses Gilbert Bay cod indicator data from 1998 - 2008 (Morris and Green 2009).

Key threats to Gilbert Bay MPA Conservation Objectives

Concentrated fishing efforts in Gilbert Bay after the northern cod moratorium in 1998 prompted community support to protect the local cod population from overfishing (Morris et al. 2002b). A process to establish a MPA was then started, with the objective to protect Gilbert Bay cod. Because many Gilbert Bay cod reside primarily within the boundaries of Gilbert Bay, establishing the MPA has been very successful in sustaining the population. However, recent data indicates that an unknown number of fish, particularly larger individuals, migrate from Gilbert Bay during summer to occupy areas outside the MPA boundaries. Fishing activities, in areas outside the MPA boundaries, remains the greatest potential threat to Gilbert Bay cod. This threat to the population increases as fishing effort and associated mortality increases in areas outside the MPA boundaries.

ASSESSMENT OF MONITORING

Indicators for Monitoring

Current State of Monfitoring Activities

Gilbert Bay, Labrador has been closed to commercial fishing for Atlantic cod (*Gadus morhua*) since 1999, and has been a designated MPA under the *Oceans Act* since 2005. However, demographic characteristics of the Gilbert Bay cod population and the movement patterns of individual fish have been studied continuously since 1998.

Selection of Appropriate and Meaningful Indicators as Related to Conservation Objectives:

Based on the biological/ecological Regulatory Conse[illegible]tion Objective (CO) of the Gilbert Bay MPA to conserve and protect Gilbert Bay cod, five (5) indicators of population change and potential human induced threats have been monitored to date:

1. Recruitment of age 0 pelagic juvenile abundance
2. Recruitment, relative abundance, and year class strengths based on age 2,3 and 4 year old Gilbert Bay cod
3. Research Catch Per Unit Effort (CPUE)
4. Movement patterns in relation to population demographics and MPA boundaries
5. Localized commercial, recreational, sentinel, and aboriginal catch rates and fishing effort.

Recruitment of age 0 pelagic juvenile abundance

There is large spatial and interannual variability in age 0 abundances monitored to date. As a result, a strong link between age 0 abundance and population status has not been demonstrated through the current analysis. Additional analysis using such approaches as spawner per recruit matrices should be explored to refine the usefulness of this indicator. Furthermore, confirmation of age 2, 3, and 4 year old Atlantic cod will strengthen linkages between age 0 and older age classes (see recommendations below).

Recruitment, relative abundance, and year class strengths based on age 2, 3 and 4 year old Gilbert Bay cod

This indicator can be used to demonstrate periods of poor recruitment (e.g. Fig. 2). While this indicator is useful – uncertainties in actual (identified) age-classes exist as a result of limited sampling. This indicator can be improved by defining the annual variability in length at age and better resolution of year class abundance through additional otolith sampling and analysis.

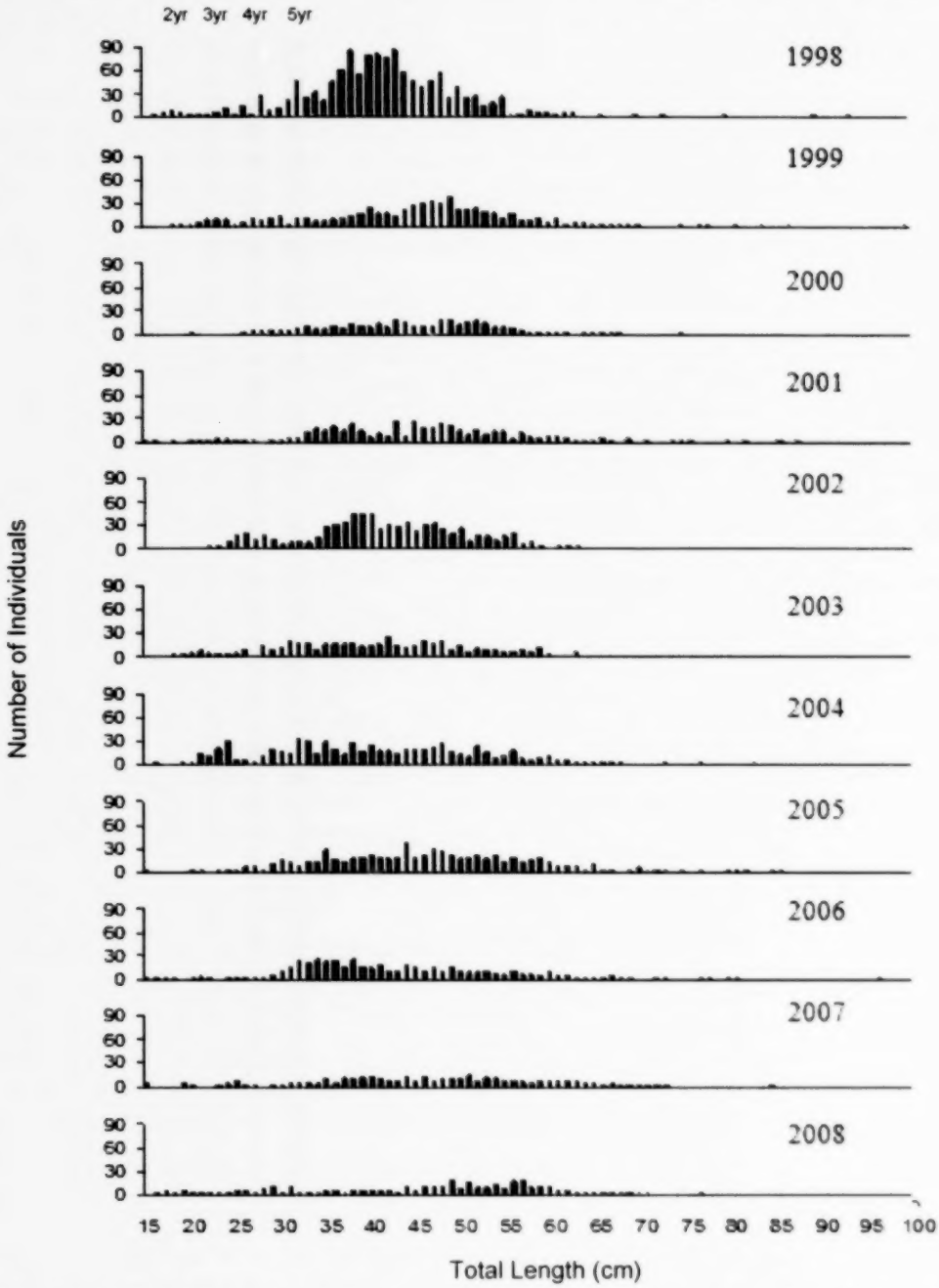

Figure 2. Gilbert Bay cod length Frequency distributions, standardized by mean annual spring sampling effort, in The Shinneys from 1998 (top) to 2008 (Bottom). Approximate fish length corresponding to ages 2-5 years are indicated.

Research Catch Per Unit Effort (CPUE)

This indicator can be used as an estimator of (proportional) fish abundance for Gilbert Bay cod. It can be improved upon by re-analyzing existing data and providing a measure of research catch rate variability among sampling sites. Provision of confidence intervals around annual catch rates will improve the reliability of this indicator.

Movement patterns in relation to population demographics and MPA boundaries

This indicator is important for determining the movement of the population relative to the MPA boundaries and to spatially variable threats (e.g. fishing outside the MPA). An unknown number of Gilbert Bay cod that move outside the MPA boundaries are becoming vulnerable to fishing pressure, as evidenced by the recapture of tagged cod during fishing activities conducted outside the MPA. Since such movement may vary from year to year, this indicator should be part of an ongoing monitoring program. This indicator is also useful for interpreting the information gained from the indirect indicator measuring fishing pressure threats.

Localized commercial, recreational, sentinel, and aboriginal catch rates and fishing effort.

This indicator demonstrates the potential for fishing pressure to directly affect the status of the Gilbert Bay cod population (Table 1). The value of this indicator can potentially be improved through use of genetic identification tools to allow greater accuracy in determining the proportion of Gilbert Bay cod being captured in various fisheries. These are currently being explored.

Table 1. Commercial Atlantic cod catches reported by Department of Fisheries and Oceans dockside monitoring program, at locations where tagged Gilbert Bay cod have been caught and reported by commercial fishermen. Fishing areas include headland areas between Salmon Point (N 52 37 44, W 055 44 51) in the north, to Cape spear (N 52 26 35, W 055 37 38) to the south, and all of Alexis Bay. The northern cod fishery was closed from 2003-2005.

Year	Fishermen with reported landings	Total catch (kg) Round Weight	% quota caught by active fishers
1998	12	8,135	60
1999	11	12,057	99
2000	3	613	5
2001	2	928	12
2002	9	5740	17
2006	10	6,598	48
2007	19	17,672	82
2008	23	17,631	67

Usefulness in Measuring MPA Effectiveness

These five indicators are either directly or indirectly linked to the identified CO and, especially in compliment, are appropriate and sufficient to assess the status of the Gilbert Bay cod population. Notably, indications of fish movement and fishing pressure outside the MPA (Table 1.), which pose a potential threat to the population's growth rate in the short and medium term, are recognized to be useful indirect indicators (in support of direct indicators or indicators of

threat) that may require modification over time as new information (or questions) on the status of the system emerge.

The usefulness of the above indicators for Management has been proven through the publication of past 'Monitoring Reports' for the Gilbert Bay MPA – and will be strengthened through the ability to consider the analysis of the above indicator data to review the *Gilbert Bay Management Plan* accordingly in 2010.

Protocols for Monitoring

Annual Sampling

Annually, two trips, approximately 2 weeks in duration, are required to carry out sampling protocols in the Gilbert Bay MPA – one during the spring (late May to early June), and one during the summer (early August). Spring monitoring targets Gilbert Bay cod spawning season at which time Gilbert Bay cod are concentrated at overwintering locations (Morris and Green 2002). Summer monitoring targets a time when fish are more dispersed (particularly adults) from their overwintering areas (Green and Wroblewski 2000), and age 0 fish are pelagic.

Research Catch Data

Research catch rates based on hook and line sampling is the preferred means of sampling Atlantic cod in Gilbert Bay as it catches nearly all sizes of cod (fish greater than 15 cm) and does not adversely impact bottom habitats. Sampling is conducted at 28 regular sampling sites distributed throughout inner-Gilbert Bay (see Morris and Green 2009), and several other locations in the bay that are sampled less regularly. The time, duration, and number of people fishing at each location are recorded. Sampling at each site consists of a minimum of 30 minutes of fishing effort and rarely exceeds 120 consecutive minutes. Sites are not fished sequentially.

Upon capture, the total length of each cod is measured to the nearest millimeter and it is examined. Examination includes gently squeezing the abdomen to check for sexual maturity (identified by the presence of eggs or milt), the gills are examined for parasites, and any net marks are noted. Healthy fish larger than 30 cm are marked with an external individually numbered tag and released at the location of capture. Recaptured cod, fish with an external tag from previous tagging, are sacrificed; however, recaptures per trip rarely exceed 20. Sacrificed fish are measured, weighted when possible, otoliths are removed, stomach contents identified and gut fullness is estimated. Data from recaptured fish provide an indication of fish movements, growth rates, feeding, and abundance.

Recruitment of age 0 pelagic juvenile abundance

Ichthyoplankton are sampled using a 1 meter diameter ring net with 333 micrometer mesh, towed horizontally through the water column for 15 minutes. During spring, egg samples are collected at depths of 2 m (surface sample), 5 m (near the picnocline) and 8 m (below the picnocline). During summer, age 0 pelagic juveniles are collected only at the surface (< 2m). Approximately 10-30 samples are collected from the same areas of Gilbert Bay (primarily in the Shinneys) during each sampling period, and are preserved in formalin and /or ethanol for analysis.

Recruitment, relative abundance, and year class strengths based on age 2, 3 and 4 year old Gilbert Bay cod

This indicator is based on relative juvenile year class strengths. Juvenile year classes are identified based on examination of modes in length frequency distributions. Few otolith samples have been collected each year, and therefore determination of the relative abundance of year classes based on otolith samples has not been possible. However, existing age-length keys approximate year classes in general. Based on these data, modes in the length distribution are assigned ages up to approximately 5 yrs, after which modal analysis is difficult due to highly variable growth rates, likely due to the onset of sexual maturation.

Tracking of the 2, 3 and 4 year age classes could be improved through the additional use of otoliths from target size classes to allow the determination of relative strength of cohorts over time. Selective sampling targeted at 2-4 years olds (approximately 80 fish total) by size, will minimize the number of fish that must be killed for this purpose while maximizing information gained. Alternatively, and if possible, previous samples should be reanalyzed for the analysis of this indicator.

Research Catch Per Unit Effort

This indicator is based on sampling rate over time. Research catch per unit effort (CPUE) is calculated as the number of fish caught during research catch divided by the number of people fishing multiplied by the time (hrs) each person spent fishing. The catch rate for each sampling period is then standardized to the average annual sampling effort for all years in the time series.

To reduce the level of uncertainly in adequately sampling the population over a long period of time, monitoring the Gilbert Bay cod population through research catch data (CPUE) should also include stations in the main arm of Gilbert Bay. While this might involve significantly more effort, it would ensure that significant changes in catch numbers are not due to an unexpected change in movement patterns, potential growth, and/or fidelity. Alternatively, additional use of telemetry to monitor movements between different parts of Gilbert Bay may be useful here.

Movement patterns in relation to population demographics and MPA boundaries

This indicator is based on tagging and recapture of Gilbert Bay cod sampled by hook and line. Further inferences are based on length frequency distributions between May and August.

Localized commercial, recreational, sentinel, and aboriginal catch rates and fishing effort

This indicator is based on recapture locations and returns of tagged fish from commercial and other sources, including recreational, sentinel, and aboriginal fishing.

Other opportunities (e.g., SeaWatch at sea observer program or Labrador Métis Nation (LMN) fisheries guardian program) to collect data and information on the take of Gilbert Bay cod in commercial, sentinel, recreational and aboriginal fisheries would prove useful to enhancing the data for this indicator.

Strategies for Monitoring

Monitoring the Gilbert Bay MPA cod population has the potential to include the collection of indicator data/information by non-DFO staff and communities. As part of the Gilbert Bay MPA, DFO currently has ongoing external collaborations with the Labrador Métis Nation and Memorial University in support of monitoring. Over the last two years individuals from DFO and MUN, that developed the Gilbert Bay monitoring protocol, have provided training to the Labrador Métis Nation in various aspects of the monitoring program. The Gilbert Bay MPA has served as a living laboratory in this capacity, providing valuable hands on training to local aboriginal personnel. In return, the LMN have provided personal and equipment to conduct the monitoring work. While this strategy has been successful, it has been determined that at least three years of training will be required to ensure a reasonable level of data quality assurance in the monitoring program. Potential problems which could interfere with this strategy include changes in long term consistent funding and potential changes in personal.

Assessment of Gilbert Bay indicator data

The indicators used in the assessment show a decline in the status of the Gilbert Bay cod population (Fig. 3). Changes in the demographics suggest that the population may decline further due to decline in reproductive potential. Given the poor recruitment in recent years, the removal of an unknown number of spawners by the commercial fishery is a concern.

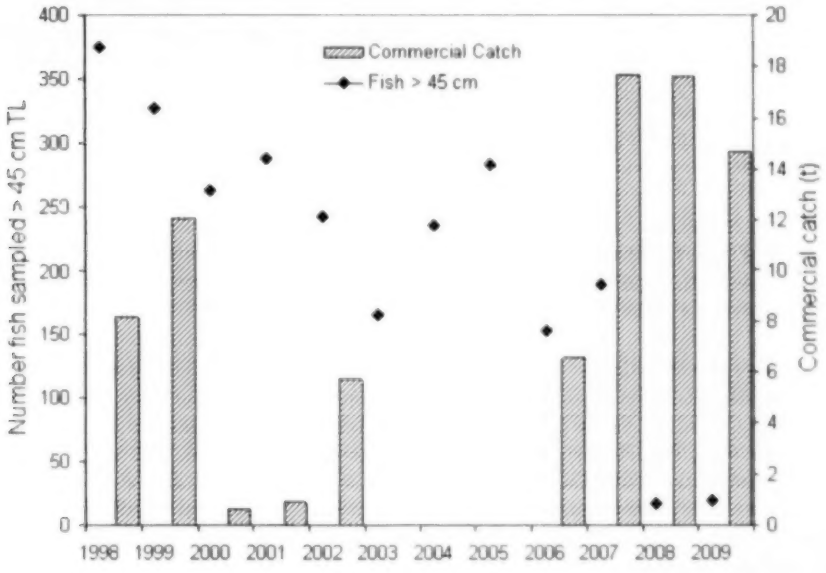

Figure 3: Standardized catch (number of individuals) and biomass (tonnes) of Gilbert Bay cod based on research CPUE from MPA monitoring (primary y axis), and commercial catch data based on dock side monitoring and research monitoring of local fishing activity (secondary y axis). MPA science monitoring is conducted at the beginning of each season, before the commercial fishing season.

Consistent with a precautionary approach, existing indicator data may be used to establish reference points. Reference levels for the population should be explored to provide a benchmark against which to determine population status.

Research is required to develop or improve indicators for monitoring natural and anthropogenic pressures on the Gilbert Bay cod population.

OTHER CONSIDERATIONS

Recommendations:

Stable funding is required to ensure that the ability to monitor indicators used in measuring the success of the MPA in meeting its conservation objective is adequate. This may also involve periodic sources of funding for capital or research costs as requirements arise, e.g. for expanded and enhanced monitoring using telemetry.

Periodic review of these indicators, protocols and strategies is also necessary to ensure that selected indicators are appropriate for measuring the success of the Gilbert Bay MPA in meeting its conservation objective(s), and for concomitant review of monitoring efforts for Management Plan reviews. This would ensure timely linkages between the two documents.

Given the broad range of ecosystem-level indices available on a regional scale, other types of ecosystem monitoring, not necessarily being conducted within the Gilbert Bay MPA, but potential drivers of the Gilbert Bay MPA regional system, may be considered with/ incorporated into the analysis of Gilbert Bay cod population trends over time. For example, climate indices, chlorophyll a, etc.

CONCLUSIONS

The five indicators currently being used to monitor the Gilbert Bay cod population, and their respective sampling and analytical protocols, are appropriate and sufficient to monitor the MPA against its Conservation Objective(s). However, some minor modifications to the existing protocols and data analysis can improve the overall monitoring program.

To increase the understanding of natural and anthropogenic influence on the Gilbert Bay cod population, indicators for other pressures on the population should also be developed. These pressures include changes in habitat, changes in prey type, abundance, and distribution (stomach contents may be useful for this), and variation in natural mortality. Given recent advances in telemetry and the current telemetric infrastructure in place for monitoring the Gilbert Bay cod population, enhancing the use of telemetry to indicate movements of large cod between the MPA and adjacent areas would prove useful to further understanding sources of mortality of Gilbert Bay cod.

An analysis of the 1998-2008 data from existing indicators suggests a decline in abundance of Gilbert Bay cod. An assessment of the demographics of the Gilbert Bay cod population also suggests that the population may decline further due to a decline in reproductive potential. Given the current status of the Gilbert Bay cod population and the indication of poor recruitment in recent years, the removal of an unknown number of spawners in the area adjacent to the MPA by the commercial fishery is a concern.

Finally, reference levels for the Gilbert Bay cod population needs to be explored to provide a benchmark against which to better determine population status in future assessments.

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